Centre of Mass, cm (or centre of gravity, cg) and Torque, τ.

Leaning tower of Pisa.

Treat F_g as acting at the centre of mass. Distance to rotation point, r, creates a torque, τ

$\tau = F \times r$

τ vector cross product

τ vector

vector

$\tau = Fr\sin\theta$

θ is angle between F and r.

units Nm (not J)

Rotational Equilibrium - the torques on an object balance

torques clockwise=torques counterclockwise

$\tau_C = \tau_{CC}$

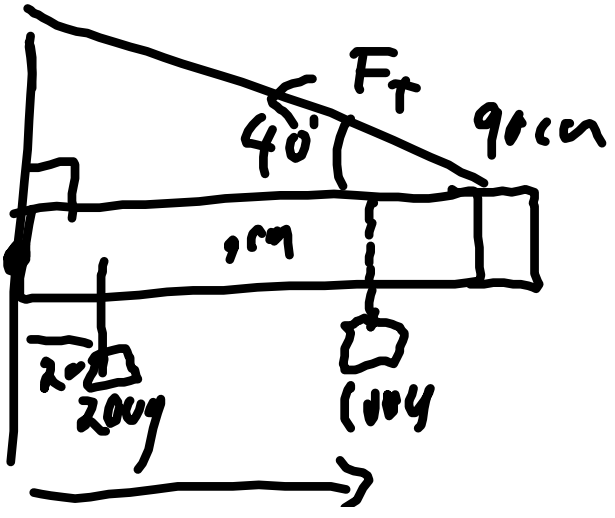
e.g. You hang a 200g mass on a massless metre stick at 20cm and a 100g mass

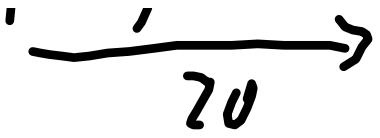
at 70cm.

a) Where is the centre of mass?

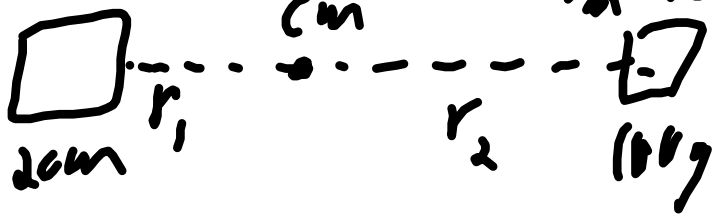
b) if the metre stick is 150g where is the cm?

c) You secure the metre stick to the wall at 0cm and with a string at 90 cm making a 40° angle to the stick. What is the tension in the string





a) $m_1 = 200g$ $m_2 = 70cm$



r_T

$r_1 + r_2 = 50\,cm$

Tcc $m_1 g r_1 = m_2 g r_2$ Tc

$r_1 = \frac{m_2}{m_1} r_2$

$\frac{m_2}{m_1} r_2 + r_2 = r_T$

$\left(\frac{m_2}{m_1} + 1\right) r_2 = r_T$

$r_2 = \frac{50}{\frac{100}{200} + 1}$

$r_2 = 33.3\text{cm}$

$cm = 70\text{cm} - 33.3\text{cm}$

$= \boxed{36.7\text{cm}}$

$$\sum M\, x_{cm} = m_1 x_1 + m_2 x_2 \cdots$$

general equation

b) Since metre stick is 150g and uniform, Set mass at centre, 50cm.

$$(100\text{g} + 200\text{g} + 150\text{g})\, x_{cm} = 200\text{g}(20\text{cm}) + 100\text{g}(70\text{cm}) + 150\text{g}(50\text{cm})$$

$$\boxed{x_{cm} = 41\text{cm}}$$